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Naval Research Laboratory

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PLASMA PHYSICS DIVISION

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PLASMA PHYSICS RESEARCH AT NRL

The Plasma Physics Division was established at the Naval Research Laboratory in 1966. The Division is a major center for in-house Navy and Department of Defense basic and applied research in plasma physics, intense electron and ion beams, atomic physics, pulsed power sources, space plasma, and laser-plasma physics.

Our research staff includes scientists from many disciplines and diverse backgrounds—working together to respond to requirements and opportunities from the Navy and the Nation.

Our research efforts concentrate on a few closely coordinated theoretical and experimental programs. We emphasize large-scale numerical simulations related to plasma dynamics. The Division is organized into six Branches formed along technical subjects.

FACILITIES

The Division has developed a variety of pulsed power sources, accelerators, and high-power lasers to provide state-of-the-art facilities for our far-reaching research interests. These include:

- PAWN, 1-MJ compact inductive storage facility
- Gamble II, TW high-voltage pulsed power generator
- Pharos III, three-beam neodymium-glass laser and target facility (1.05 μm and 0.53 μm)
- 1000-J CO_2 laser
- Dense Z-pinch facility
- High-power relativistic klystron and gryotron facilities
- Modified betatron accelerator
- Charged particle beam (CPB) propagation range
- SuperIBEX, 5-MV, 100-kA, 40-ns CPB generator
- Maxibeam 3-MV, 60-kA, 300-ns CPB generator
- NIKE, 3.0-kJ KrF laser (operational in 1993)

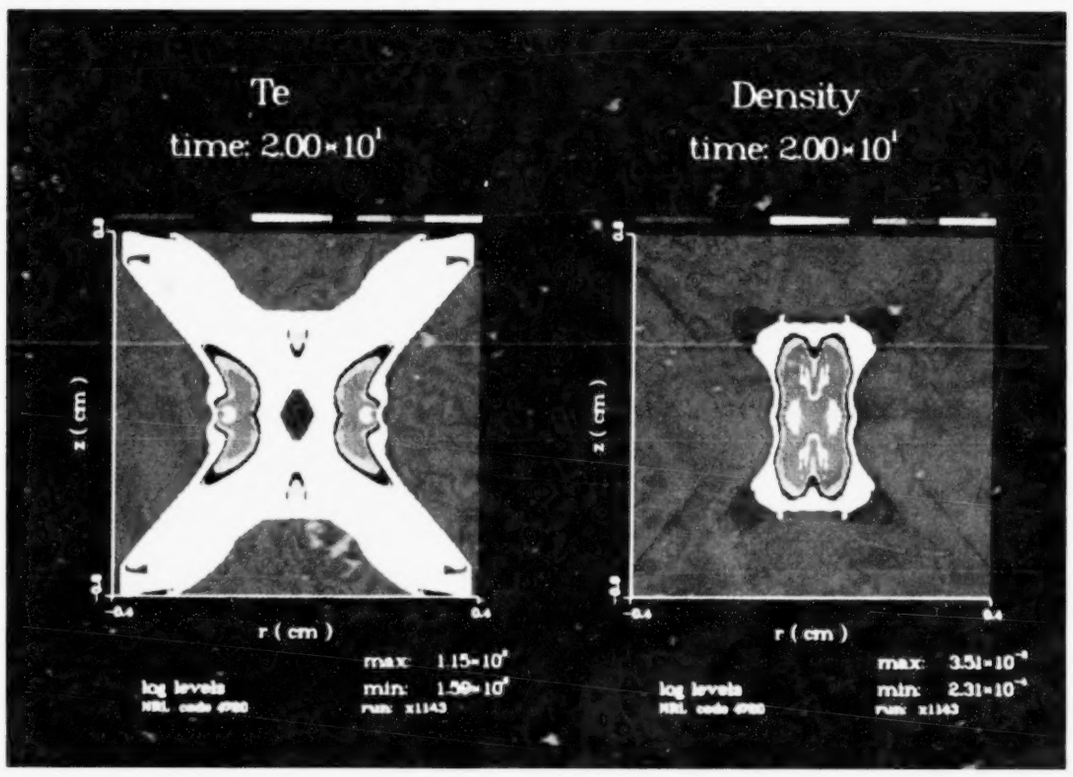
Cover: The charged-particle dynamics in Earth's magnetotail is chaotic. The teardrop-shaped phase-space area shows the striated fractal pre-image of different exit modes. Such fractal structures can profoundly influence magnetospheric plasma dynamics.

SPECIAL PROJECT FOR NONLINEAR SCIENCE

This is a multidivision program that encompasses several research areas in which nonlinear phenomena have critical effects. Current research includes chaos, nonlinear dynamics, models of nonlinear devices, signal detection, and distributed hierarchical processing systems.

RADIATION HYDRODYNAMICS BRANCH

This Branch performs theoretical and computational research in the areas of nuclear weapons effects simulation, directed energy target interaction, dense plasma physics, atomic physics, and plasma spectroscopy. The principal emphasis is on developing advanced computer models that combine hydrodynamics, magneto-hydrodynamics, and radiation physics. The Branch participates in X-ray laser modeling and design, laser propagation through disturbed environments, the physics of strongly coupled and degenerate plasmas, and strong field effects on fundamental atomic phenomena.



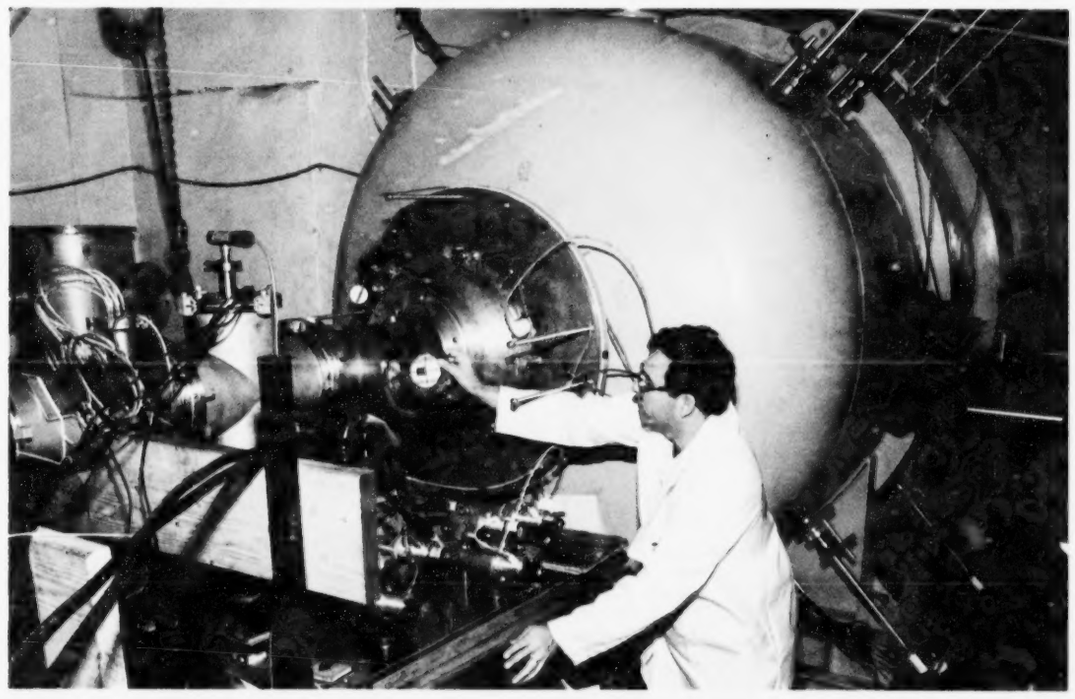
Temperature and density behavior of a copper X-pinch at 20 ns as it is compressed by a current of ~5 MA

LASER PLASMA BRANCH

This Branch develops high-power lasers, primarily krypton-fluoride (KrF) lasers, and uses these lasers for laser-target interactions, especially laser fusion. The construction of the NIKE 3.0-kJ, 248-nm KrF laser facility funded by the Department of Energy is scheduled for completion by 1993. The Branch conducts both experimental and theoretical research of relevance to the Navy, to other areas of the Department of Defense, and to the Department of Energy's defense programs. The research activity includes laser-plasma interactions, laser-plasma diagnostics, and strongly coupled plasma.

CHARGED PARTICLE PHYSICS BRANCH

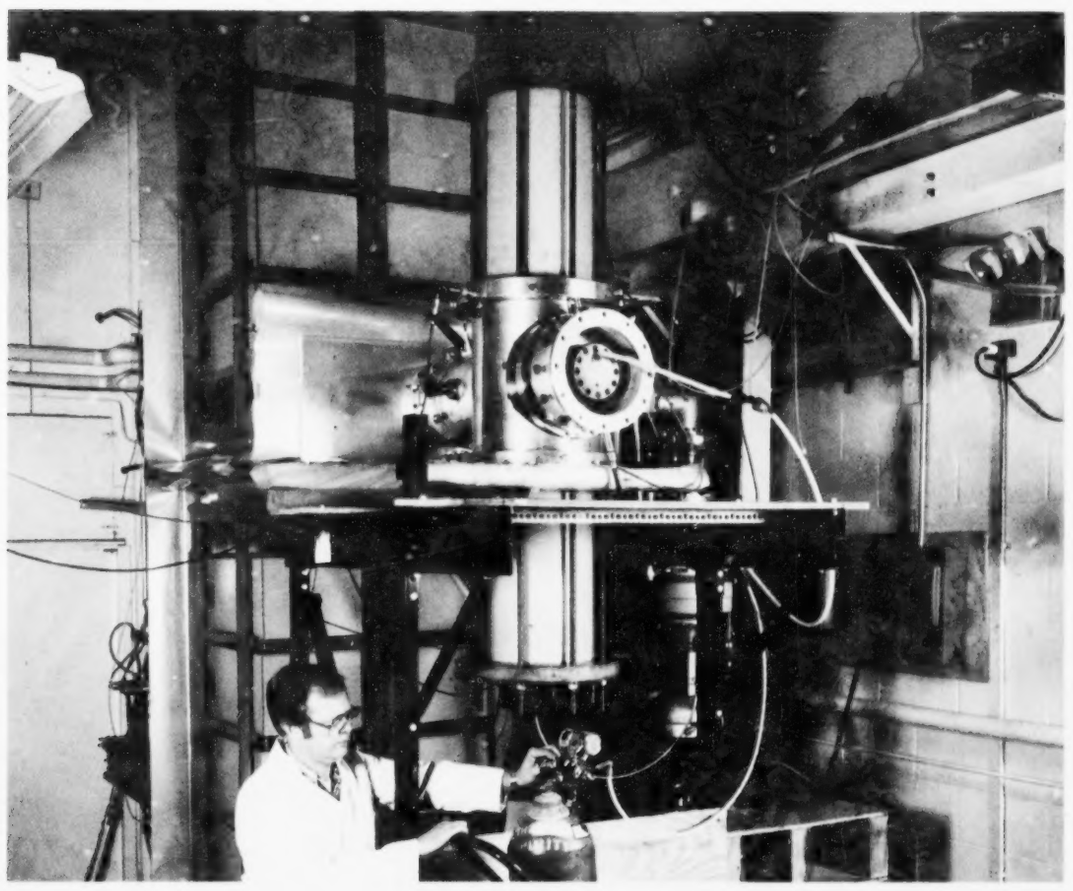
This Branch conducts experimental research on directed energy, pulsed energy technology, and high-current discharge physics by using state-of-the-art pulsed power devices. Directed energy research includes the production and study of high-power charged particle beams (CPBs). Pulsed energy technology includes investigations of electromagnetic and electrothermal mass drivers and high-energy density materials for high explosives and energy production applications. High-current discharge research includes investigations of both dense Z-pinches and gaseous discharges.



The SuperIBEX CPB generator injects high current electron beams into this propagation chamber. Diagnostics at the input and along the chamber are used to measure beam quality and propagation stability.

PULSED POWER PHYSICS BRANCH

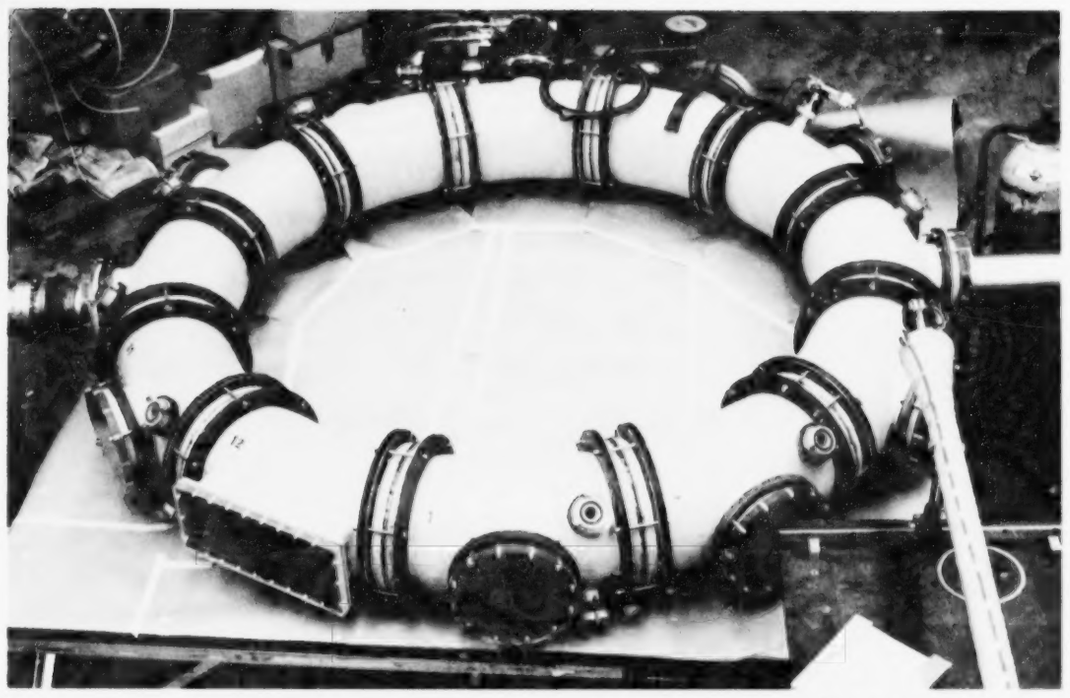
This Branch is concerned with the development of high-energy, pulsed power systems that use capacitive and inductive energy storage and with the production and application of pulsed plasmas and intense high-power charged particle beams. It provides the technological basis for high-energy-density plasma experiments, high-power switching, advanced radiation sources. It also advances applications of this technology to other areas such as nuclear weapon effects simulation and directed-energy weapons.



PAWN, 1-MJ compact inductive storage facility

SPACE PLASMA BRANCH

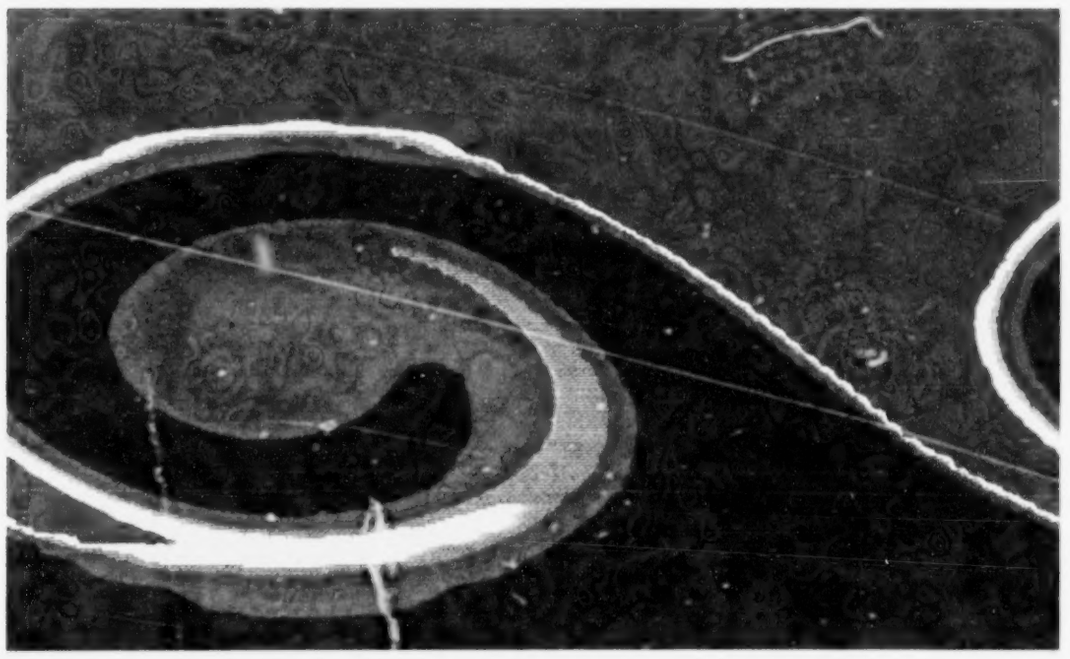
This is a multidisciplinary group that performs experimental, theoretical, and computational laboratory and space plasma physics research. Areas of investigation include active and natural space and astrophysical plasmas, high-altitude nuclear effects, laser-produced plasmas. X-ray lasers and propagation, and space plasma instrumentation for rocket and satellite-borne experiments. Analytical methods and large-scale computer simulations are used to study the coupled system of solar wind, magnetosphere, ionosphere, and the atmosphere. Ionospheric modification is studied by using chemical releases and radiowave heating.



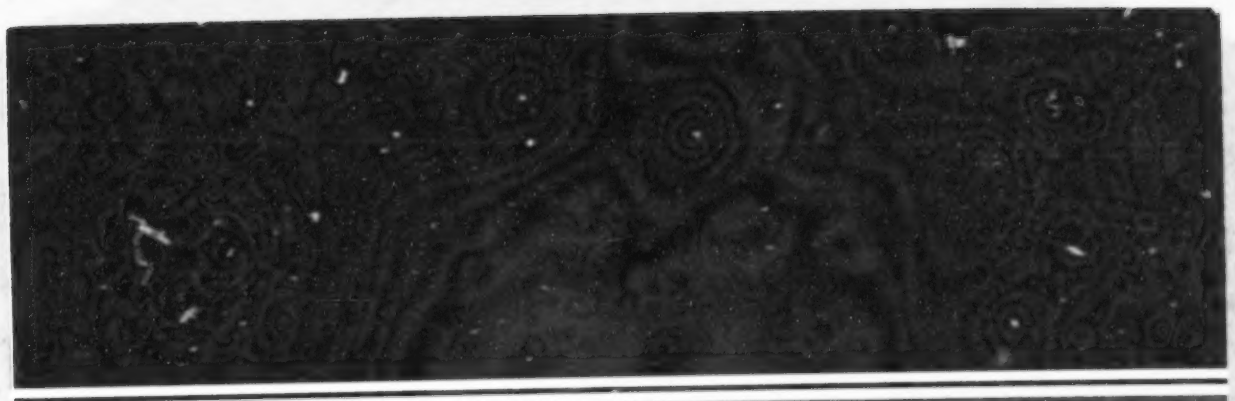
NRL-modified betatron accelerator produces electron beams with peak current of 1.5 kA and energy of 18 MeV

BEAM PHYSICS BRANCH

This Branch conducts theoretical, experimental, and computational research in the areas of advanced radiation sources, advanced accelerators, and beam propagation physics. Primary areas of current research include coherent radiation sources (gyrotrons, cyclotron masers, and free electron lasers), compact accelerators (modified betatron and spiral line accelerator), advanced accelerators (laser-plasma driven), and electron beam propagation in the atmosphere.



Nonlinear evolution of density-gradient-driven plasma interchange instabilities generated in the high-latitude ionosphere



PLASMA PHYSICS DIVISION

(Area code 202)

Superintendent	
Dr. S. Ossakow	767-2723
Associate Superintendent	
Dr. V. Patel	767-2997
Program Administration Office	
Mrs. T. Mason	767-2727
Special Project for Nonlinear Science	
Dr. P. Palmadesso	767-6780
Senior Scientist Fundamental Plasma Processes	
Dr. W. Manheimer	767-3128
Senior Scientist Controlled Fusion Research and Applications	
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Dr. B. Ripin	767-3379
Beam Physics Branch	
Dr. P. Sprangle	767-3493

Reviewed and approved
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Sidney L. Ossakow

Superintendent
Plasma Physics Division